Problem Set 1 Monday June 16, 2003

Problem 1:

1a) Calculate the total charge stored and maximum stored energy of a 7 GeV, 100 mA beam in a storage ring with a 3.68 μs revolution period (The APS ring nominal operating condition).

1b) Calculate the average power of the beam delivers in (1a) assuming it is dumped in one revolution period.

1c) Calculate the average power the beam delivers in (1a) assuming it is slowly scraped in 100000 revolution periods.

1d) Calculate the average power of a 7 GeV, 100 mA Energy Recover Linac (ERL) beam.

1e) Which beam is more damaging to accelerator components if it is missteered?

Problem 2:

2a) Calculate the total photon power (in kW) for a 7 GeV, 100 mA beam passing through a storage ring bending magnet source with a 30 m bend radius.

2b) Assuming the dipole is L = 3 m long calculate the power per unit bend angle for the dipole source in 2a.

2c) Calculate the critical energy for the bending magnet source in 2a.

2d) Estimate the spectral function $S(\omega/\omega_c)$ at the critical frequency using the low and high frequency approximations to $S(\omega/\omega_c)$.

2e) Estimate the power per unit frequency for the bending magnet source in 2a at the critical frequency ($\hbar$ = 6.582 x 10^{-19} keV s).

Problem 3:

3a) Calculate B_{max} and K for the APS undulator A which has λ_{ID}= 3.3 cm and g = 5 mm.

3b) Calculate the total photon power for a 7 GeV, 100 mA beam passing through undulator A (3a) assuming N = 70.

3c) Calculate the undulator rms angular divergence for the first harmonic for undulator A (assume 7 GeV, 100 mA and K = 0.1).

3d) Calculate the power in the first harmonic per unit solid angle for the parameters listed in 3c.

3e) Calculate the first harmonic power per unit area using the answer in 3c and 3d at 50 m.

Problem 4:

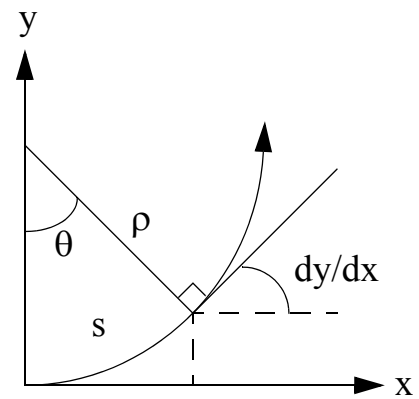

Figure problem 4

4a) Consider a charged particle moving in a constant magnetic field perpendicular to this page (see the figure). Write an expression for the bend angle θ in terms of the arc length parameter s and the radius of curvature ρ.

4b) Write the rectangular coordinates of the point (s,ρ) in terms of s and ρ.

4c) Derive an expression for the slope of the tangent to the charged particle path dy/dx in terms of s and ρ.

4d) Write to 3rd order in (s / ρ) the difference between dy/dx and θ.

4e) What is the maximum angle θ such that approximating the angle of the particle trajectory with respect to the x axis $\Delta x' \sim dy/dx \sim \theta$ is good to 1 %?

Problem 5:

In a drift space, charged particles follow straight lines. Given that the beta function in a drift space can be parametrized as

$$\beta(s) = \beta^* + (s-s^*)^2/\beta^*$$

explain why the formula

$$x(s) = [W_x \beta_x(s)]^{1/2} \cos[\psi_x(s) - \psi_{0x}]$$

is the equation for a straight line.